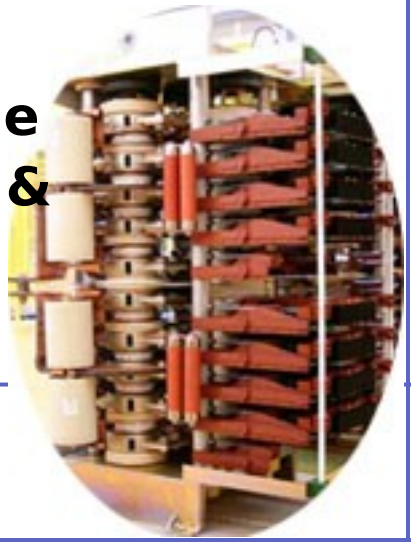
Advanced Electrical Power System Science & Technology Review & Workshop



A DUST Approach to the Development of Power Electronic Building Blocks

November 5-7, 2002

Peter Reichmeider

Senior VP & General Manager

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01/09/16

Why does the ONR / ABB cooperation w

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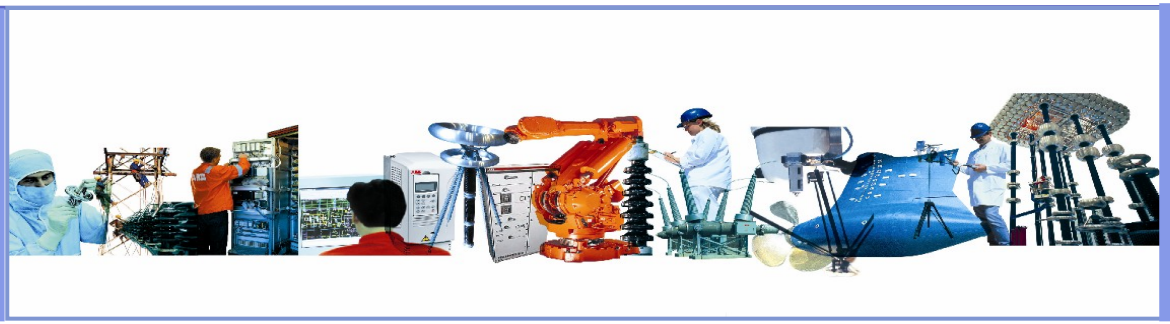
Facts about ABB



- A leading power and automation technology company with broad industry knowledge and geographic scope
- About 150,000 employees in more than 100 countries
- Leading position (1, 2 or 3) in each industry we serve and within our product areas
- Headquarters: Zurich, Switzerland
- Orders in 2001: US$ 23.8 billion
- Revenues in 2001: US$ 23.7 billion
- Listed in New York (NYSE), London/Zurich (Virt-x), Stockholm (Stockholm Exchange) and Frankfurt (Xetra)

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ABB‘s Global R&D Laboratories

Automation Technologies
SE, US, CH, NO, DE, IN

Power Technologies
CH, US, SE, CN

Engineering & Manufacturing Technologies
DE, FI, PL, US

Oil & Gas Technologies
NO, US

Over $1B Annually in R&D

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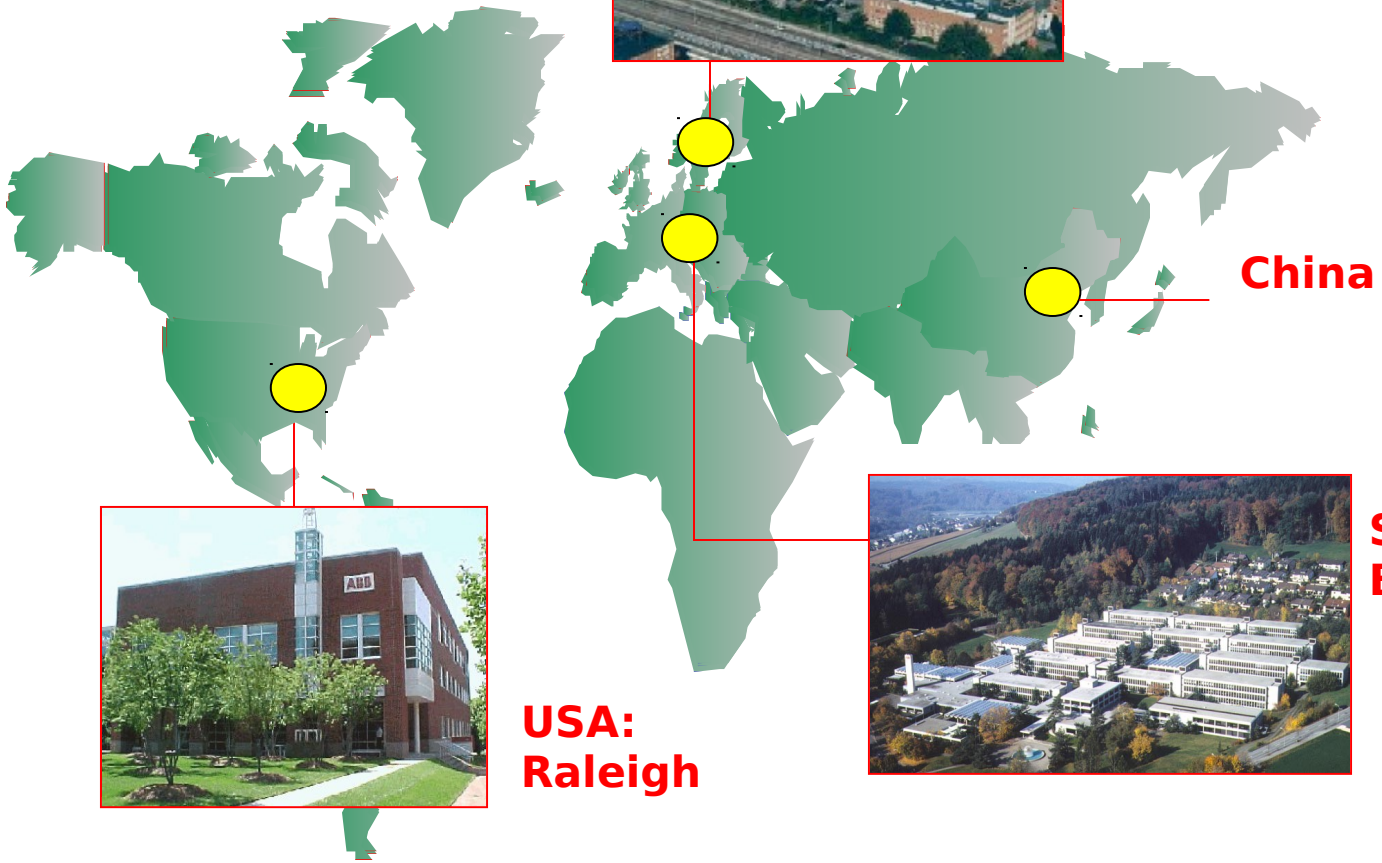
Power Tech Lab: Locations

3 main locations

Sweden: Västerås



China

USA: Raleigh

Switzerland: Baden-Dättwil

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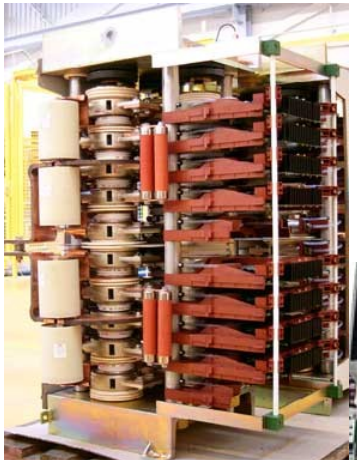
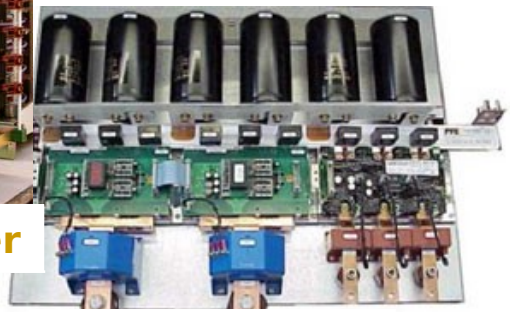
Power Electronic Applications



IGCT Converter



IGBT Converter

Flexible AC Transmission
Power Quality

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MARKET DRIVERS

Commercial Market

- Modularity/ Flexibility
- Increased Power Density
- Reduced Development Time for New Technology
- High Volumes Naturally Reduces Cost

Department of Defense

- Modularity/ Flexibility
- Increased Power Density
- Reduced Development Time for New Technology
- Low Volumes - DOD leverages the commercial market to reduce cost:
  - COTS technology
  - Installed technologies & skilled supplier personnel are supported by industry rather than DOD

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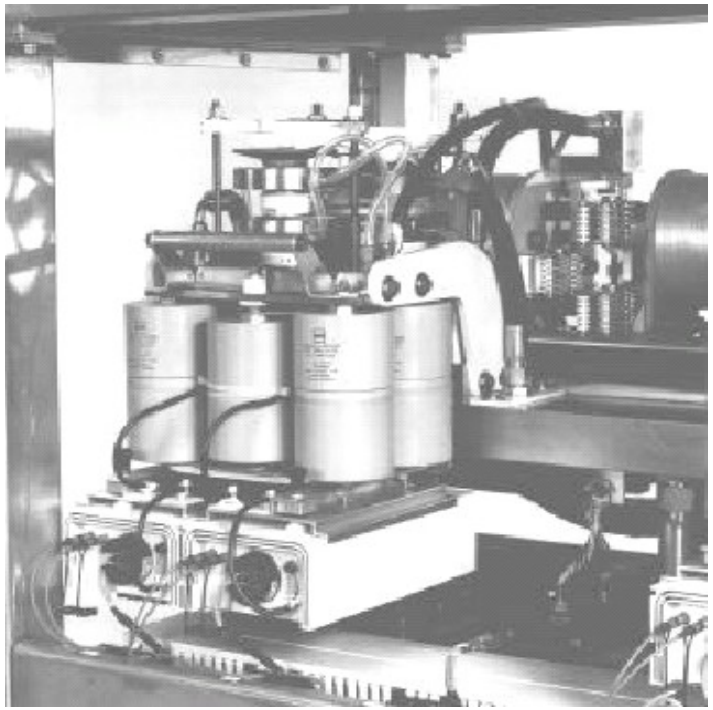
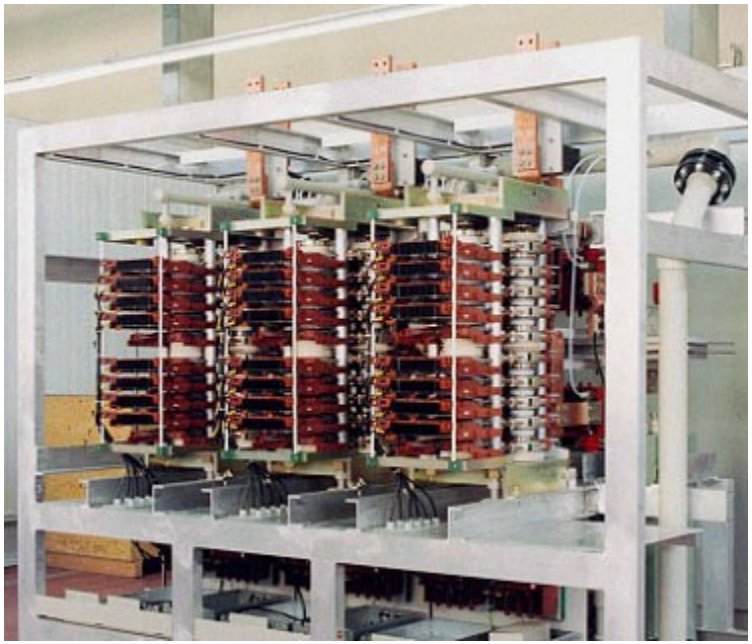
Development of Power Electronics



GTO thyristor converter
in 1985



IGCT based converter
in 2002

Power Density has improved by a factor of 4

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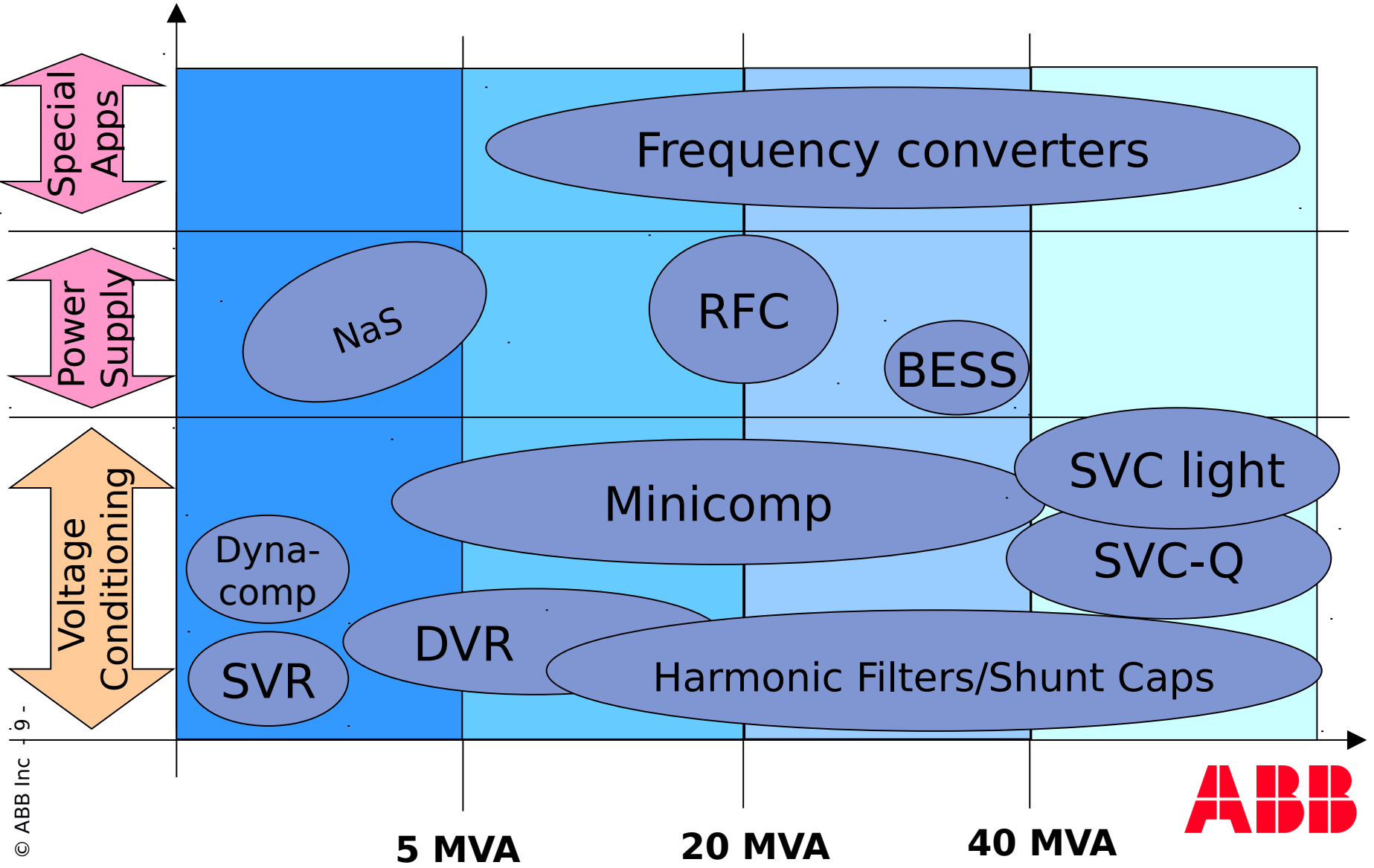
Power Conditioning Solutions Portfolio



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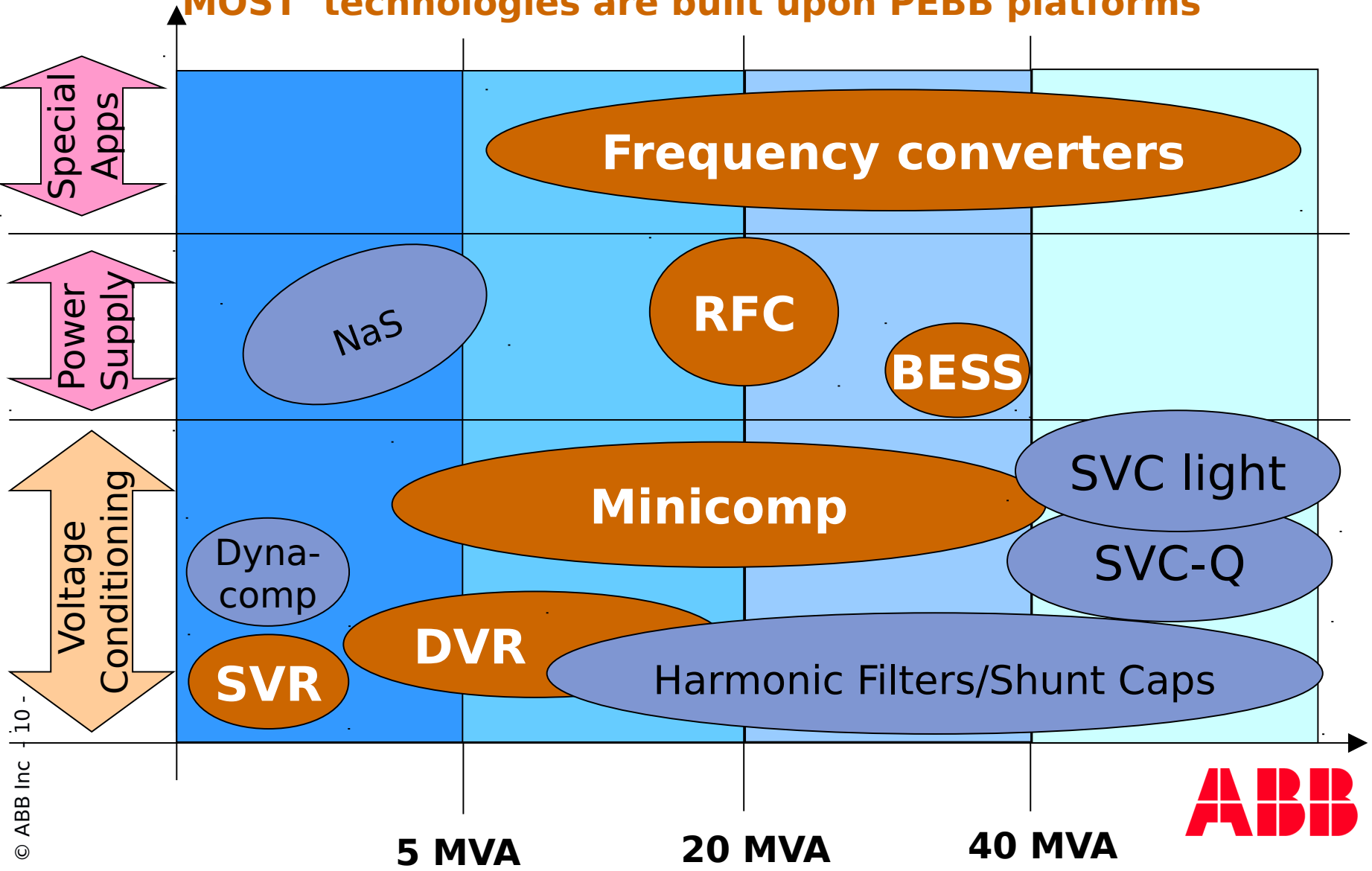
Power Conditioning Solutions Portfolio



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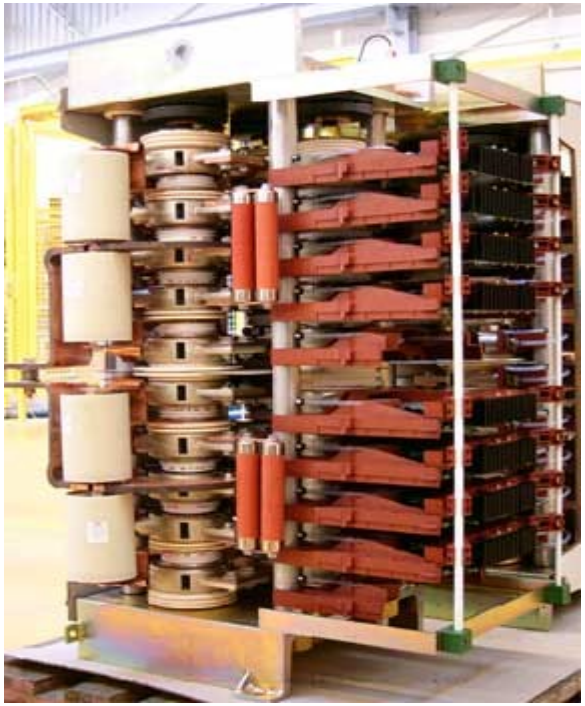
Power Electronic Technologies

- Built around Power Electronic Building Blocks (PEBBs) developed with the US Office of Naval Research
- PEBB is a standardized power electronic **module** used to build converters



PEBB's are the at the heart of ABB's power electronic platforms

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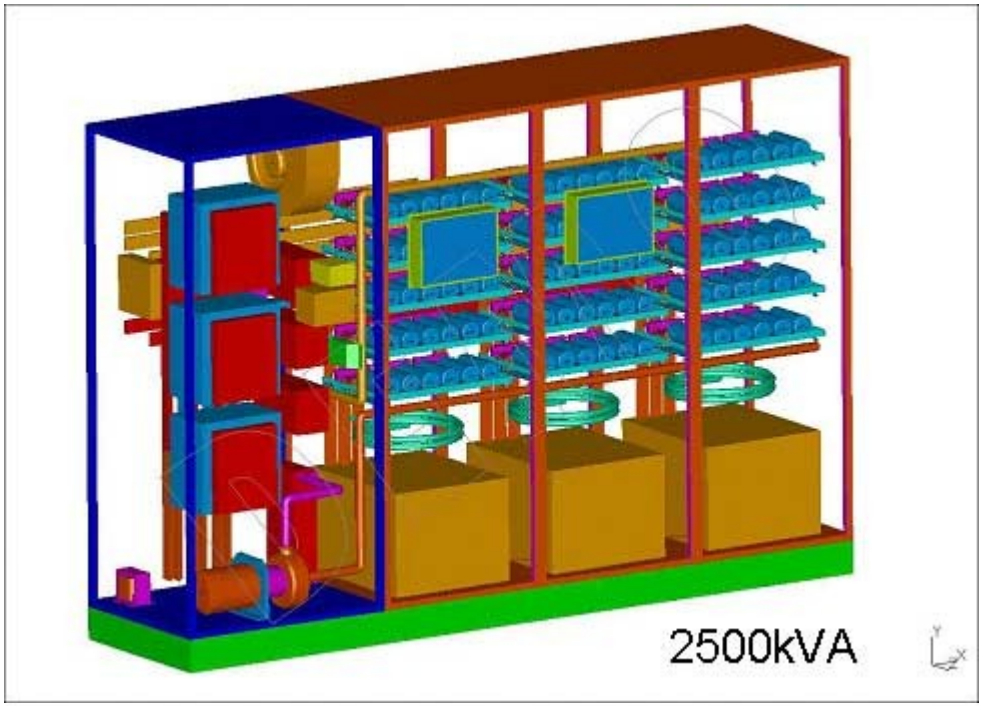
PEBB Approach to a Power Quality Device

- Series Voltage Restorer
- Modular Product Family: 500, 1000, … 2500 kVA



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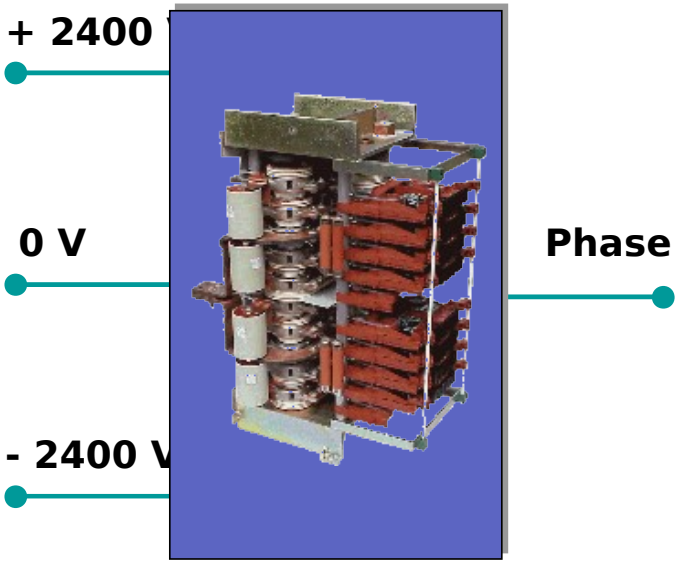
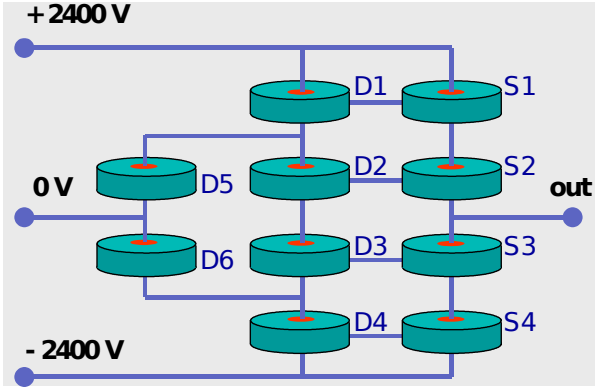
Standard High Power PEBB



Standard PEBB 9 MVA contains

- 4 IGCTs S1 - S4 (incl. Gate-Unit)
- 6 Diodes D1 - D6
- 2 Clamp-Diodes and -Capacitors



Operating Area

- U_{phase} = 3300 V_{rms}
- I_{phase} = 1600 A_{rms}
- f_{pwm} = 600 Hz
- P_{out} = 9 MVA @ f_{line} = 50/60 Hz

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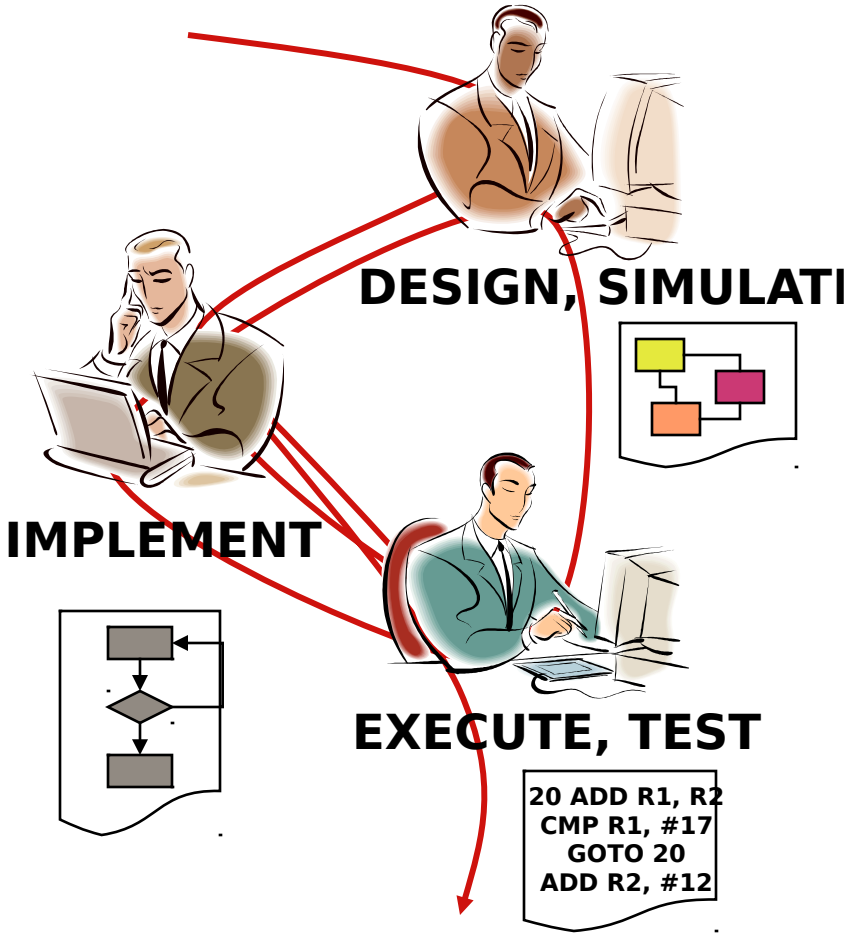
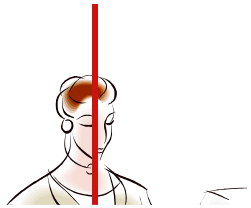
Control Development

How it used to be:



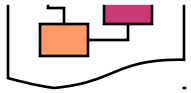
With OPCoDe:



Optimized **P**rocess for
Control **De**velopment

⇒

Engineering Efficiency



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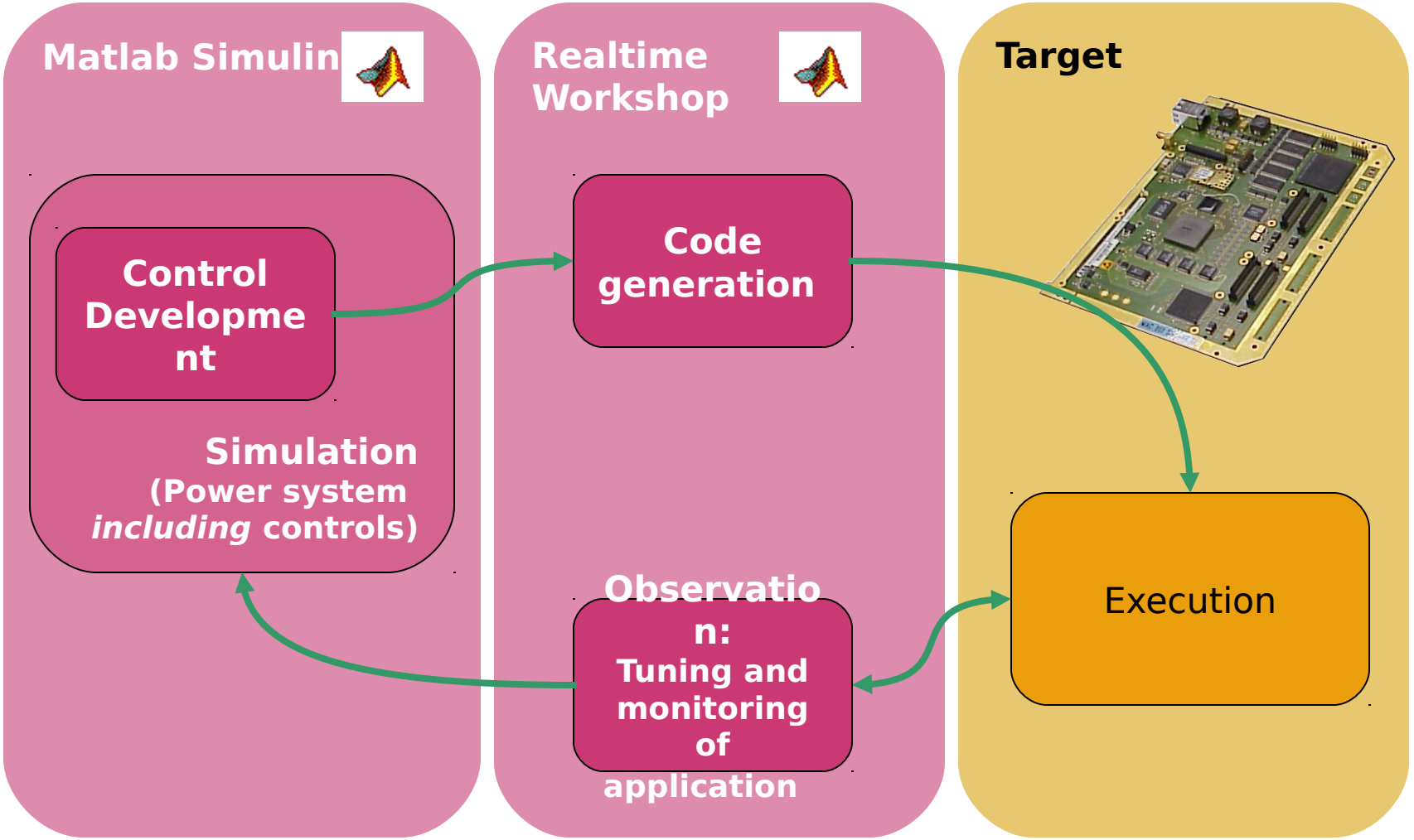
Control Development



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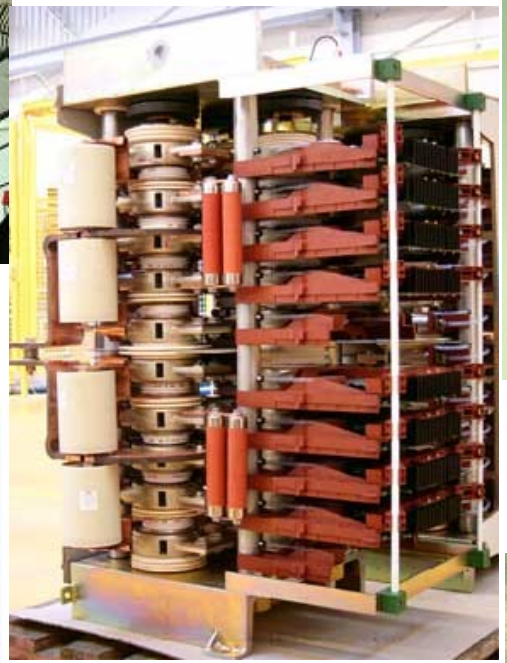
Recent 9MVA PEBB Utility Applications

Chip Manufacturing Plant, Israel
DVR (Dynamic Voltage Restorer)



TVA - Regenerative Fuel Cell (RFC)

Deutsche Bahn, Germany
Frequency Changers (FC)

GVEA ALASKA - Battery Energy Storage System (BESS)

GVEA ALASKA - Battery Energy Storage System (BESS)

Problem

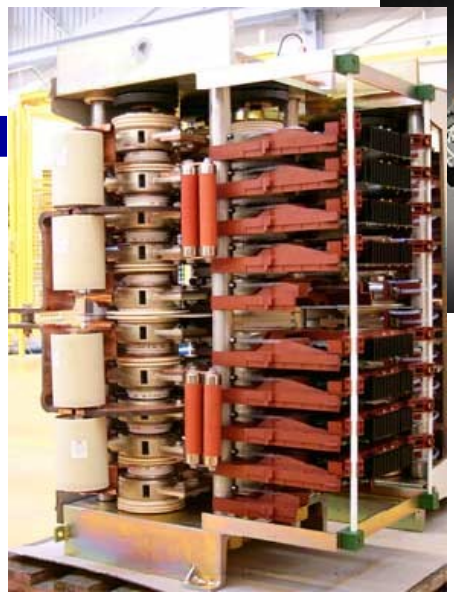
- System disturbances caused customer interruptions/voltage collapse (blackouts @ -40º F)

Solution

- Turnkey 40 MW battery energy storage system to provide rapid response to system disruptions
- Global consortium led by ABB with batteries from Saft

Benefits

- Avoids expensive and polluting conventional alternatives
- Provides voltage support during normal operations and back-up energy during system disruptions



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Alaska BESS Power Electronics

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TVA - Regenerative Fuel Cell (Regenesys)

Source :

www.innogy.com

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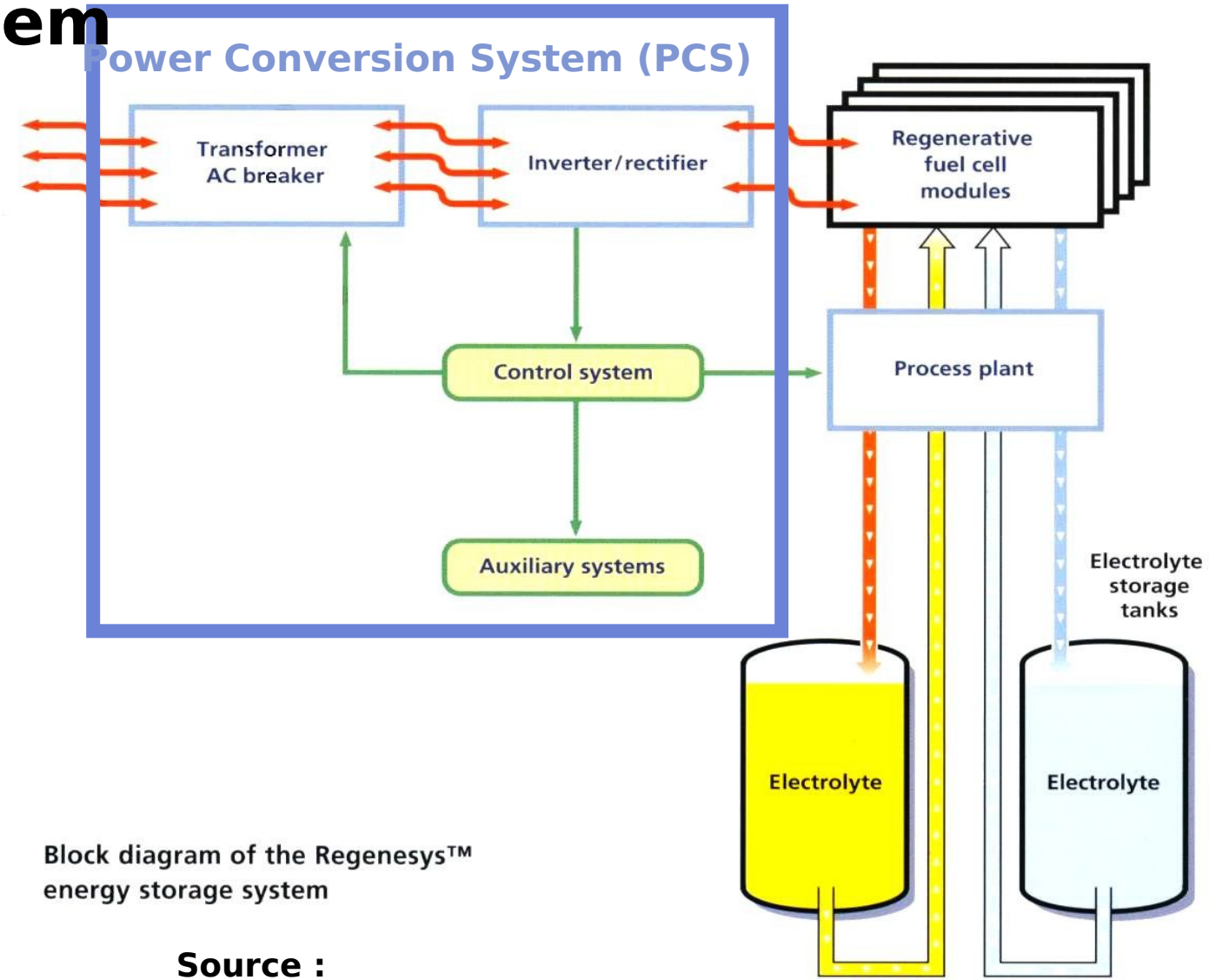
Main elements of the Regenesys storage system



Block diagram of the Regenesys™ energy storage system

Source :

www.innogy.com

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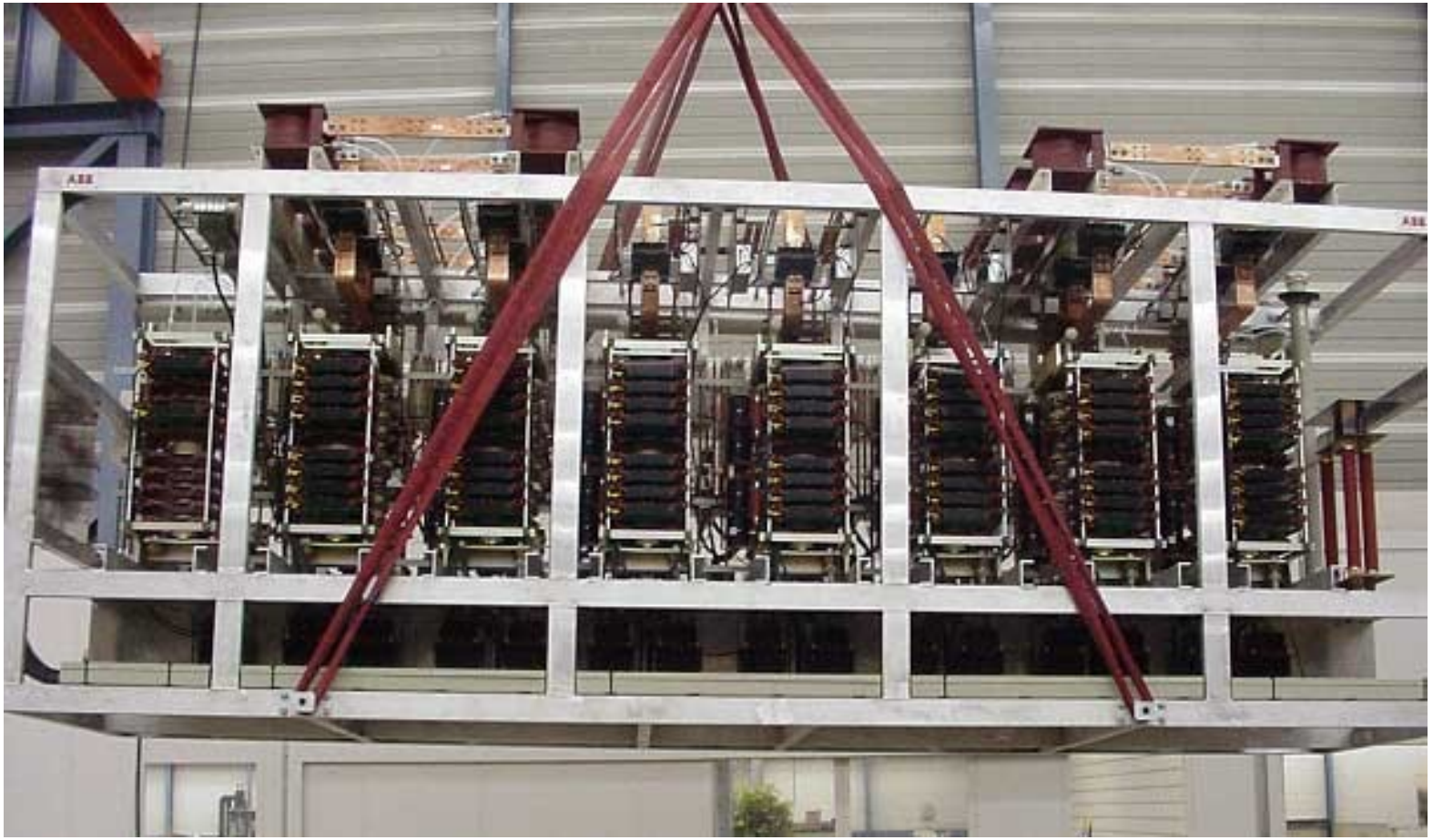
TVA - RFC Power Electronics



Combined Voltage Source Converter & Chopper in a modular, compact and scalable design

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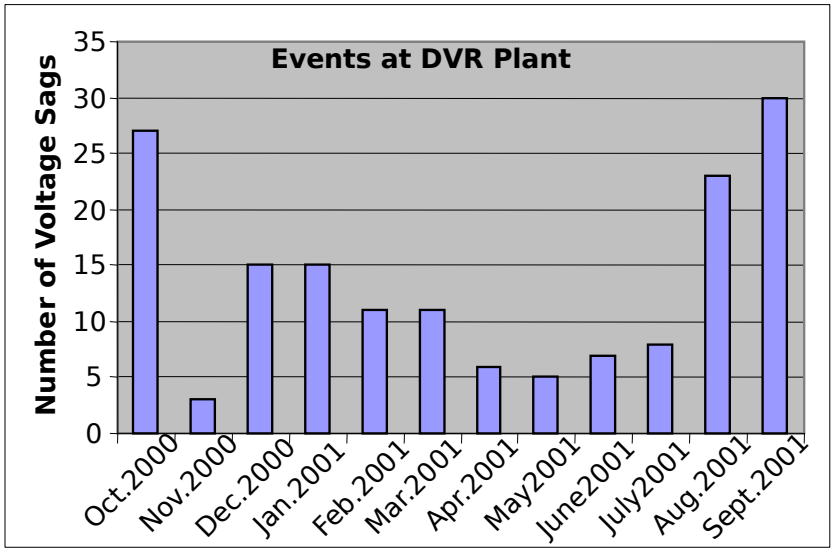
DVR - Chip Manufacturer Plant in Israel



Plant size: 2 units, 22 MVA each

Events per year: ~150

Estimated costs per disturbance: up to $1 Million

Payback in ~ 6 months

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SVR - 1500 kVA Prototype

- Testing completed in August 2002

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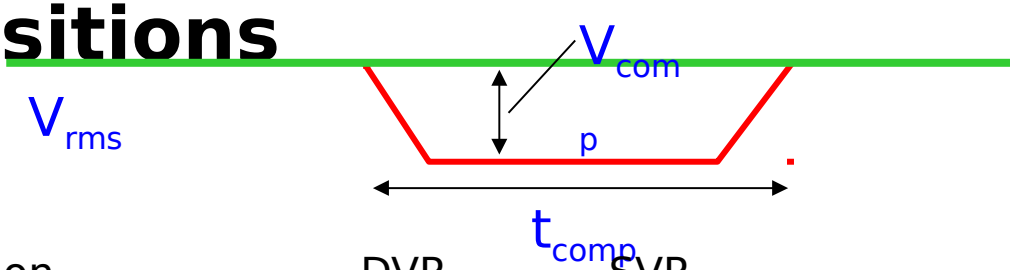
Design criteria and value propositions



Specification	DVR	SVR
Connection voltage (typical)	< 15kV (medium voltage)	600 V or less (low voltage)
Protected load power	**10-25 MVA**	**0.5 - 2.5 MVA**
Protection level	facility	targeted load
3-phase sag compensation	35%	38%
1-phase sag compensation	50%	50%
Compensation duration	0.5s	0.5-2s
Continuous voltage regulation	no	optional
Reactive power compensation	no	optional
UPS functionality	no	optional

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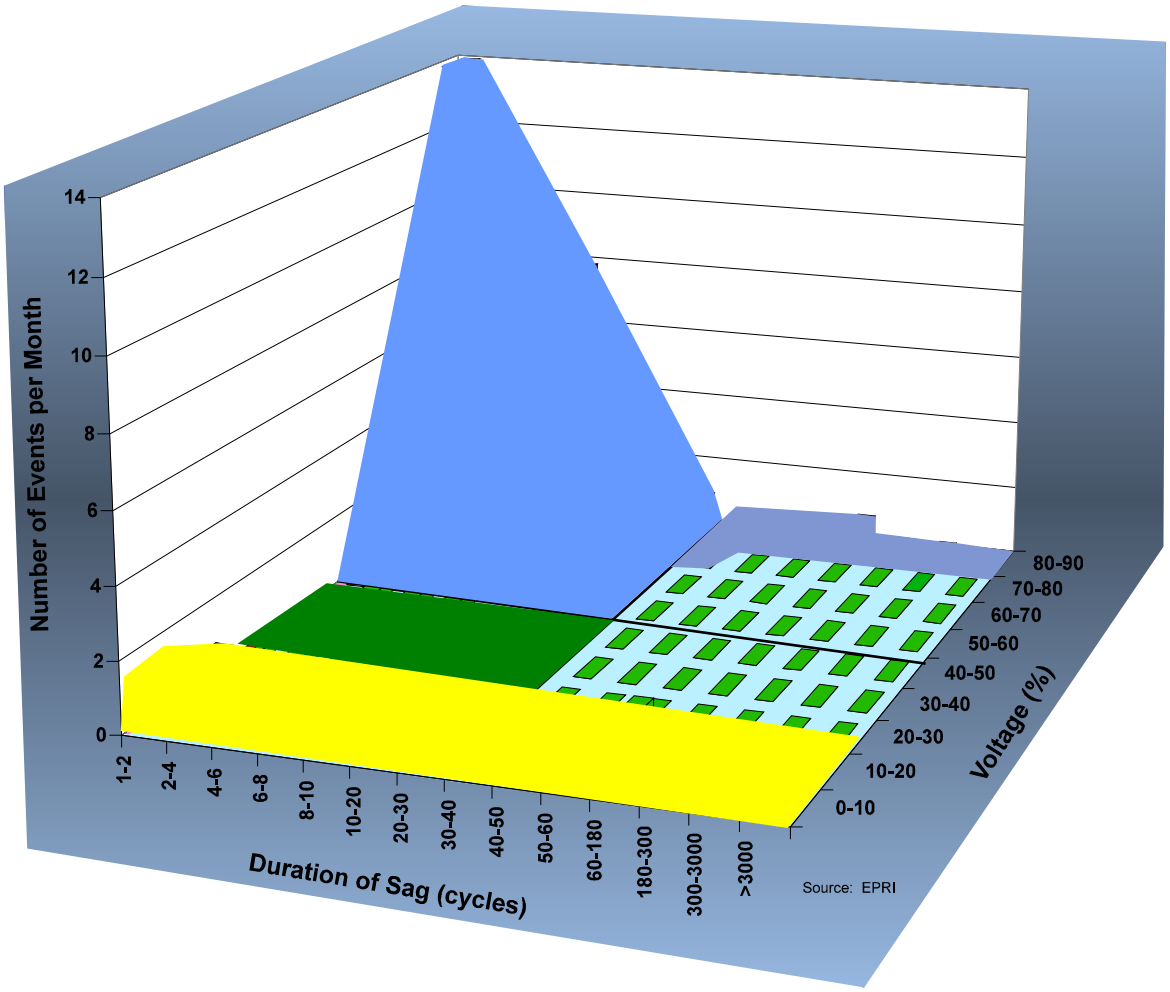
SVR Performance



Frequency of events at the average industrial site

- Covered by standard SVR
- Covered by SVR performance option
- Improved performanc with additional energ storage (capacitors)
- Requires additional energy storage

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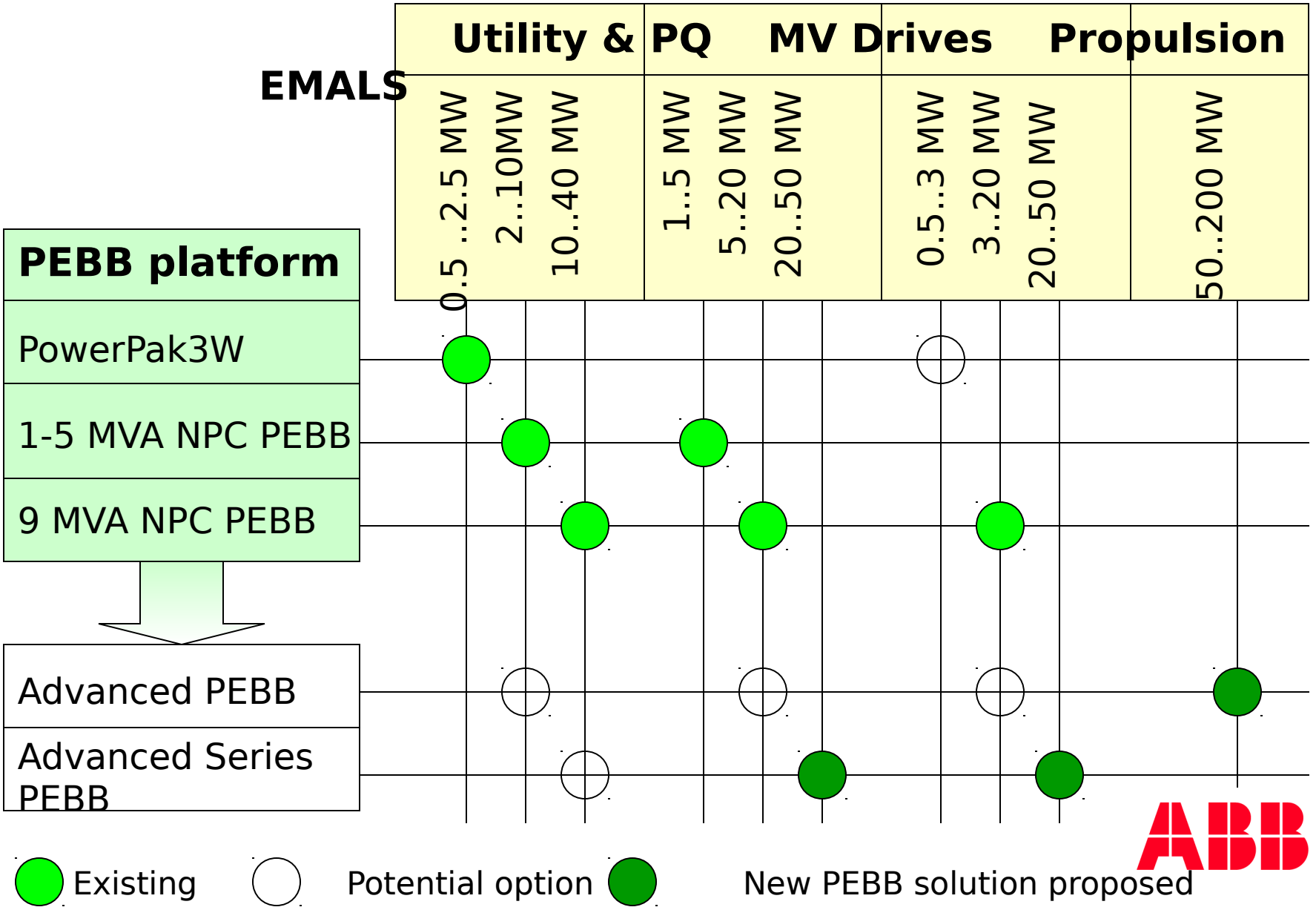
DOD Technology Insertion Potential



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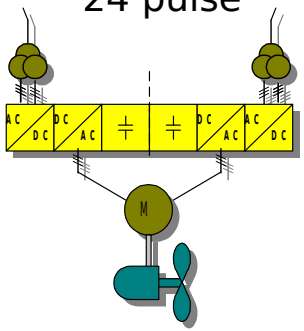
Propulsion - ACS 6000

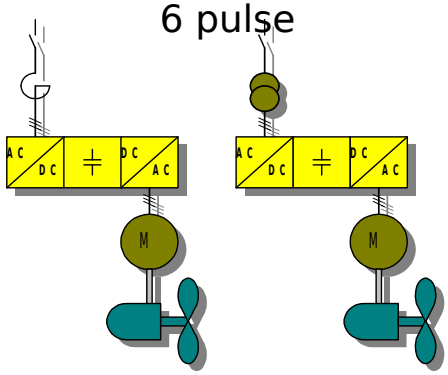
Typical 30 MVA for Marine applications

Common DC- bus with two inverters (redundant drive)

24 pulse



6 pulse



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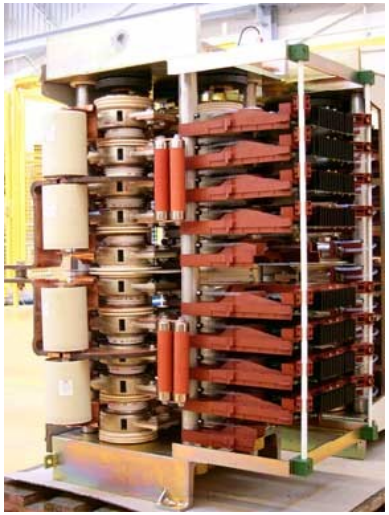
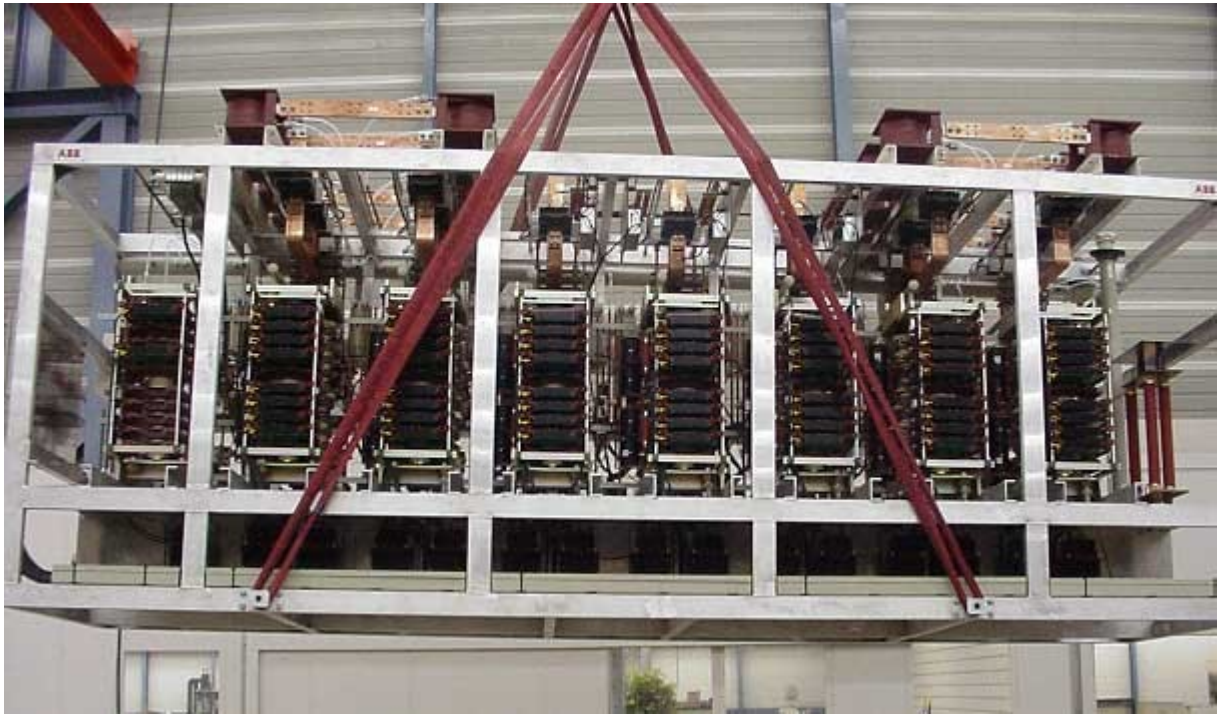
Phase Leg Test Device - EMALS & Propulsion





Step 1

- Build 12,000 Amp phase leg using 9MVA standard PEBBs and commercial standards
- Develop test bed for Advanced PEBB
- Develop plug & play criteria for EMALS

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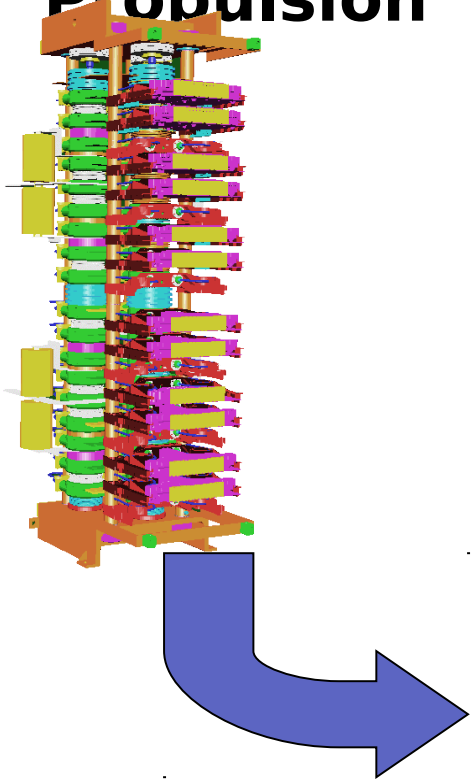
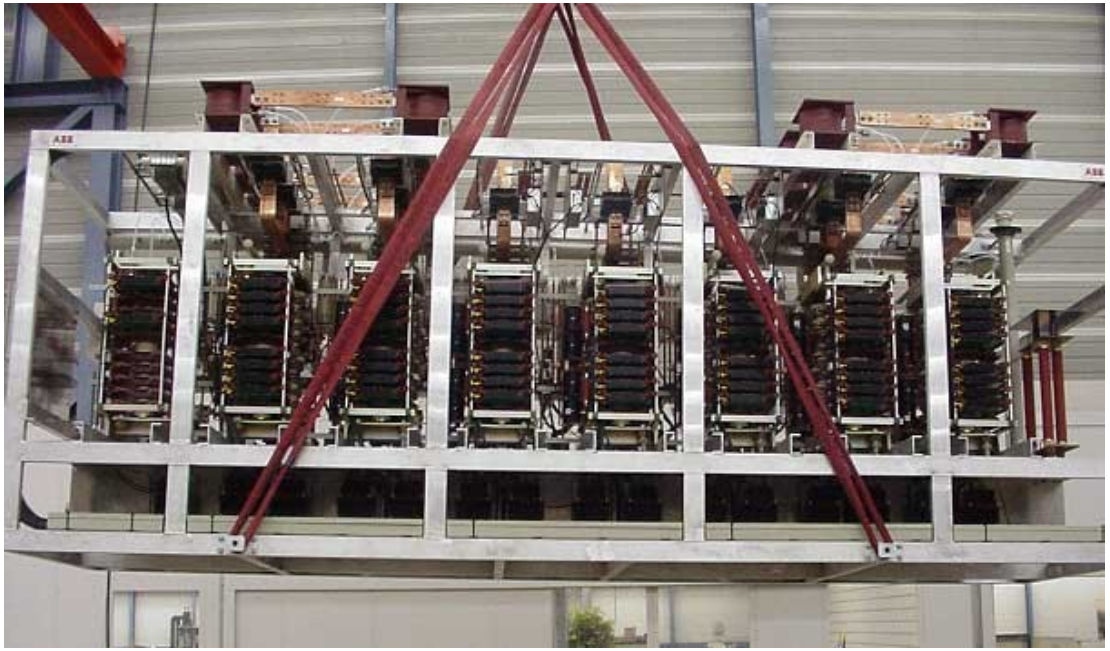
Phase Leg Test Device - EMALS & Propulsion





Step 2

- Develop advanced PEBB technology – Under ONR S&T program
- Insert advanced PEBB into phase leg/test bed to demonstrate higher power capability
- Validate performance and benefits

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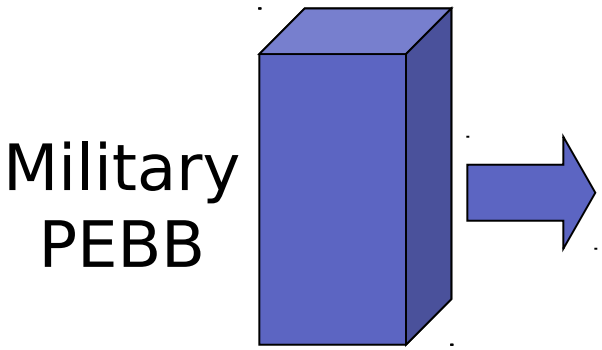
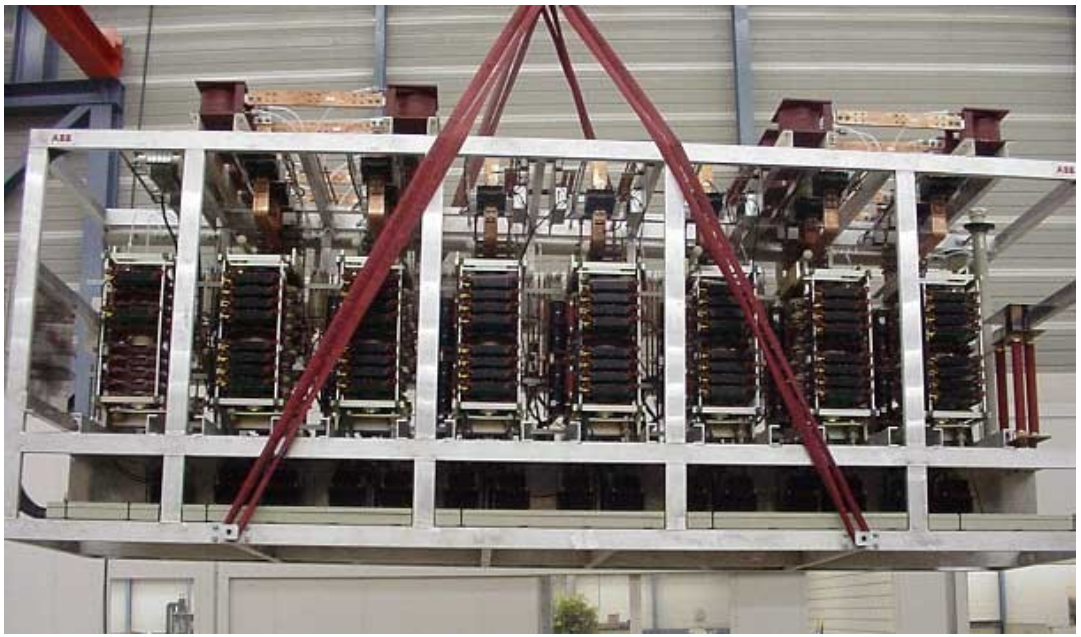
Phase Leg Test Device - EMALS & Propulsion





Step 3

- Use as a load simulation test device driven by other technologies
- Demonstrate interchangeability
- Create Military Plug & Play PEBB in cooperation with a defense contractor

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Summary

Why does the ONR / ABB cooperation work?

- Technology driven
- Common and overlapping goals
- DUST

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